ENGINEERING CASE LIBRARY

ECL 234

INTERNATIONAL 500

The development of farm machinery requires a great deal of testing and ingenuity. This case illustrates how the International Harvester Company went about updating one of its product lines.

Sears Roebuck & Co. Circa 1900

 By G. Kardos, Carleton University, Ottawa, Canada. Prepared by G. Kardos and L. Bougner. The assistance of Mr. J. Lepp of International Harvester Company of Canada Limited is gratefully acknowledged.

INTERNATIONAL 500 (A)

"If Sales don't like the Mark 1, let's fly in a stylist from Chicago and have him design a streamline manure spreader". This was Hugh Mackenzie's way of initiating International Harvester's six year development program for a new manure spreader in 1967.

International Harvester is a large multi-national company with headquarters in Chicago. The company is a primary producer of farm machinery and light industrial equipment. Its headquarters and central research divisions are located in Chicago, but the various plants throughout the world have sole responsibility for design and development of specific product lines. International's Canadian plant, located in Hamilton, Ontario, has exclusive responsibility for International's line of loggers, manure spreaders, snowblowers, grain drills, windrowers and various tillage machines.

The company is continually involved in developing newer and better products. Information on new trends in farm practice and feedback about existing products from sales and from the field, is continuously analysed, as they become available, to determine the company's response. This analysis and the response is the responsibility of the Product Planning Committee. The committee, comprising of the Chief Engineer, the Works Manager, and sales representatives of the product lines, meets at regular intervals to review existing development projects and to establish new projects.

Hugh Mackenzie was the product engineer for the manure spreader line at the Hamilton works. Hugh had received his Bachelor of Agricultural Science in 1955 from Guelph University and in 1956 a Bachelor of Applied Science. Since then he has been with International Harvester, in Hamilton.

Livestock farmers routinely return livestock manure to the land. For this they use a manure spreader. Most spreaders are single axle units with power takeoff, which are drawn behind tractors. These units account for

80% of the market, the remaining 20% are wheel driven spreaders and large tandem and truck driven units. A manure spreader has basically two working elements: a beater which simultaneously chops and disperses the manure uniformly over an area, and an apron which moves the manure from the front of the spreader box to the rear into the beaters. Manure spreaders come in several sizes, dependent on box capacity.

It is the practice at International Harvester to redesign a product line every 5 to 10 years. This is necessary because both the profit and the share of the market tend to decrease the longer a product remains unchanged. The existing line of manure spreaders was introduced in 1963, and the new line should be available in 1973. In 1967 the Product Planning Committee decided to initiate a six year development program for a new line of manure spreaders - the series 500.

The existing spreaders were generally satisfactory, but there had been some complaints about beater claw failures and broken shafts. Problems had also occured with the ratchet drive for the apron. The drive produced a jerking intermittent motion which was both noisy and subject to failures. One of the objectives set for the development program was to eliminate these difficulties.

Once the Product Planning Committee authorized a redesign, a Product Engineer is assigned, in this case Hugh Mackenzie, who is responsible for the design and development of the product. In August 1967, Hugh presented his proposals for the development of the 500 series spreader. It was to consist of 130, 160 and 190 bushel single axle spreaders with power takeoffs. He proposed that the use of tongue and groove boards, and plywood paneling be abandoned in favor of an all steel spreader. He also suggested that the availability of hydraulic cab control in tractors warranted consideration of a completely hydraulic driven spreader. The Product Planning Committee considered Hugh's proposal and gave their approval.

Although Hugh presented his first proposal in August 1967, the origins of the 500 series go further back. At the time of Hugh's presentation a first prototype " *Mark 1*" (Exhibit I) was already being tested in the Hamilton area. The Mark I resembled the existing line of spreaders very closely. It did incorporate the continuous apron drive with corrosion resistant sides but retained most of the old features, such as a plywood floor.

Five months of field testing had demonstrated that the Mark I was functionally satisfactory. However, no one at International Harvester was excited about it. It was so much like the existing unit that neither sales nor engineering were enthusiastic. In fact, the sales department did not like it at all, regardless of its performance.

It was this that prompted Hugh to come up with his unique approach for a new manure spreader design. International Harvester maintains a staff of stylists in Chicago who develop the styling for many of International's products. Hugh arranged to have a stylist flown in from the head office. Hugh explained the basic function of the spreader and described the additional features he wished to add. The stylist took this information and produced sketches for a new manure spreader. The result (Exhibit II) was a good looking *"streamlined"* manure spreader, which combined function with style. It was noted that *"styling is part of the new trend in farm equipment; all spreaders do a fairly comparable job, consequently styling can be the distinguishing feature."*

Hugh had the stylists' spreader built as prototype Mark II (Exhibit II). The new series 500 line would be different from the old spreader line, and it could arouse interest within both the engineering and sales departments. As well as looking different, the Mark II incorporated the new engineering features:

(1) A hydraulic apron drive

(2) 26" in lieu of 22" main beaters

(3) One position axle, both horizontal and vertical

(4) 20" wheels only

(5) 8 ga. widespread paddles

(6) Power takeoff with a built in slip clutch

(7) Cab control

(8) No lubrication required except for rear apron shaft bearings

Once built the Mark II displayed one unwanted feature; it would cost almost twice as much to build as the projected selling price.

Mark II was field and track tested in all types of conditions during most of 1968 and early 1969. Hugh was especially interested in obtaining tests on the hydrostatic apron drive, the power takeoff declutch of the beater drive, and in isolating any structural weaknesses of the manure spreader.

As a design develops, the product engineer initiates the testing to be carried out by the Test Engineering Group. The testing requirements are formalized by raising a "*test docket*" which outlines the tests to be carried out. The Test Engineering Group then has complete responsibility for all field and laboratory testing. Field testing is carried out on various farms located in the United States and Canada, where the implement is subjected to actual year round operating conditions. The laboratory testing takes place in Hamilton where the company maintains its own extensive testing facilities, including a torture track. Here the implements are subjected to loads much greater than they would receive in normal use. The laboratory and field results are written up as a response to the test docket. The product engineer rectifies any problems which may be reported by the test engineer and authorizes any further test required.

G. R. Burkholder, the test engineer in this case, found the basic Mark II acceptable, although many detail design problems were discovered during testing. Burkholder found that structurally the spreader was much

too weak and flexible, which resulted in failure in both the axle and the front supports. These would have to be redesigned.

The Mark II had served its purpose. Its racy appearance had aroused interest in both the sales department and engineering. It had demonstrated that something new in manure spreaders was possible. In addition it had provided a test bed for a number of new engineering features. However, its high cost assured that the Mark II would not be the next generation of production spreaders.

Hugh Mackenzie took a step back to reality to create a more marketable unit. The Mark III (Exhibit III) was designed and the prototype produced in October, 1969. It benefited from the experiences gained with the Mark II. It was structurally a significant improvement over Mark II; and it cost considerably less to produce. Hugh had reduced the flexibility by beefing up the hitch channels and front cross members. He made many substantial cost reductions by sacrificing some of the Mark II's styling features. All of the functional advantages were retained, including the hydrostatic apron drive.

The Mark III spreader was tested throughout 1970 at the Hamilton test facilities, and on nearby Ontario farms. One of the major changes that Hugh had made was in the beaters. He had increased the beater paddle angle and had added to the number of paddles. Because of this he asked one of the test engineers, I.C. Moore, to make torque and power measurements on the beater shaft and the apron shafts during field testing. This was done by using strain gauges to the shafts and making readings while the spreader was operated with the different types of manure available on the farms .

The tests on the Mark III showed Hugh that he was on the right track. He could now foresee what the new production spreader would look like. There were still some major problems with the beater paddles and the axle, but generally the Mark III performed well functionally and structurally. Hugh arranged for the beater and axle assembly to be tested separately in the Hamilton test laboratory to solve the beater problem. Meanwhile he started

the design on the Mark IV (Exhibit IV) which was to be the final prototype for the production model. The beater development and the field testing of the Mark IV would take place concurrently. Once a satisfactory design for the beaters was developed, the field units would be changed.

The Mark IV was not a single spreader; it was four. The Product Planning Committee had decided that the five hundred series would have four models; a 145 bushel, 185 bushel and a 215 bushel, with mechanically driven aprons and a 215 Bu. with a hydraulically driven apron. A prototype of each was built. They differed little from the Mark III. The hitch members were strengthened again. Double flare fittings replaced the single flare fittings on the hydraulics, and a vented plug was used in the beater gear box to prevent leakage. Again, some styling features were sacrificed to retain the functional features and to lower costs.

The four prototypes were finished in November , 1970. Two were sent to Wisconsin for testing and two to Southwestern Ontario. Meanwhile, structural tests of the beater and axle assemblies were started in the test laboratory in Hamilton. The field units were given a severe test for 18 months in all types of conditions. Several of the farmers admitted using the test spreaders in conditions where they would not have used their own.

At this point Jack Lepp took over as product engineer on the manure spreader when Hugh Mackenzie became the Chief Test Engineer. Jack Lepp held the patents on International Harvester's 1963 single beater spreaders. Like many of International's engineers, he comes from a farm background, in fact, he spent several years operating his own farm in Manitoba. He received a degree in Mechanical Engineering from the University of Manitoba in 1950. He returned to his farm until 1958, because of the shortage of jobs, at which time he joined International Harvester.

The objective of field testing was to subject the spreader to all the different conditions that are likely to be encountered. Consequently, the test engineers did not leave the spreaders on any one farm, but moved them about from farm to farm to subject them to as wide a variety of manures and environmental conditions as possible. While these field tests were being

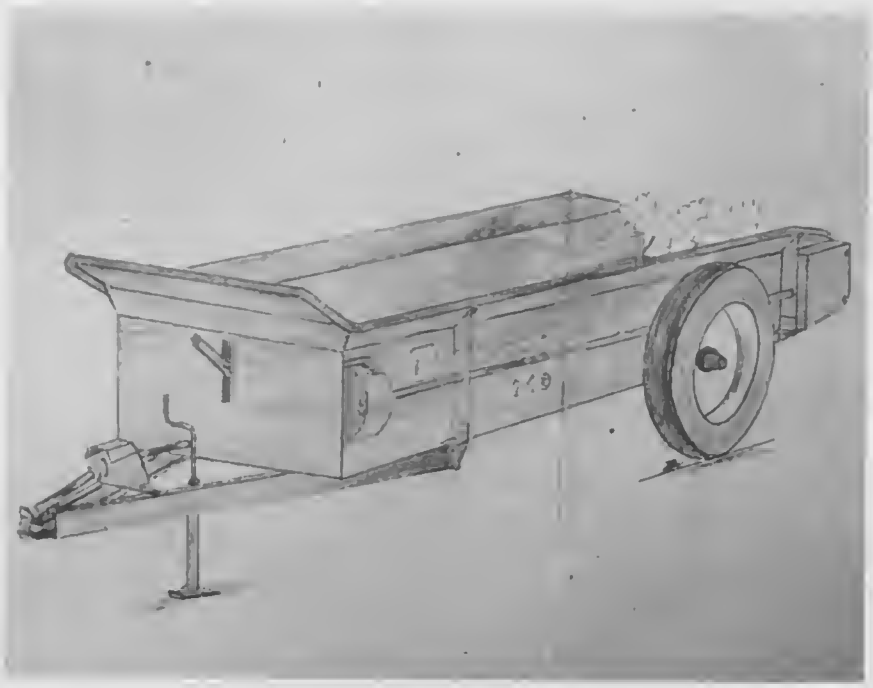
carried out, Jack Lepp received the laboratory results on the axle and beater assembly. This led to further changes which were again tested. The changes were then incorporated into the test spreaders in the field.

The response from the farmers who used the prototypes was satisfactory; the units had performed well in the field. Gordon Bolegoh, the field test engineer, recommended that Jack approve the 500 series for production. On the basis of this recommendation Jack suggested to the Product Planning Committee that the series 500 manure spreader production be undertaken in accordance with the Mark IV design.

When Jack's design was complete and approved by the Production Planning Committee, it faced one last hurdle. International Harvester requires that each new product undergo a Value Analysis review before it is put into production. The objective of a Value Analysis review is to ensure that the production costs are a minimum without affecting the function of the design. The Value Analysis Team is made up of one engineer, one planner from the factory, a cost accountant and a representative of mechanical tooling. The objective of the V.A. team is to reduce the cost of producing the product by at least 10% without, in any way, affecting its functional performance. The team goes through the design in detail evaluating each piece for function and cost. On the basis of their study they make recommendations as to changes in the design. The changes are assessed by engineering, and if necessary, are prototyped and tested before they are incorporated in the final design.

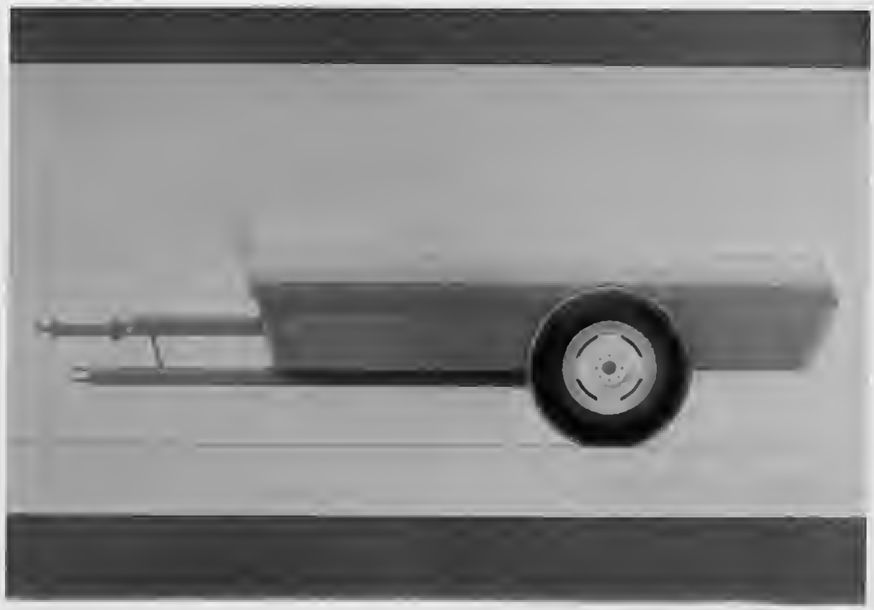
The Value Analysis team on the 500 series manure spreader met in 1971 and suggested 11 changes that would cut costs on the final product. These were tested by Mr. Bolegoh (Exhibit V) all but one were found to be acceptable and were incorporated in the design.

The new 500 series manure spreader (Exhibit VI) went into production in 1973.



MARK I PROTOTYPE

EXHIBIT I



MARK II STYLIST'S SKETCH

MARK II PROTOTYPE

EXHIBIT II

MARK III PROTOTYPE

EXHIBIT III

MARK IV PROTOTYPE

EXHIBIT IV

ECL 234 A

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HAMILTON WORKS

DEPARTMENT / DISTRICT OFFICE / WORKS Engineering Department

HAMILTON, ONTARIO

August 16, 1972

MR. N. O. Olsson

LETTER

SUBJECT OR FILE NO. Final Report

Docket:	1135
Basic Model:	7222 Spreader, 121 cu. ft.
Project Title:	Structural Test for Production Approval of Value Analysis Components

Introduction

A Value Analysis Program on the 7222 Spreaders in 1971 resulted in a number of cost reduction items that required track testing.

See list of items in Appendix as supplied by the Design Group.

Items (T1-B-3), (T2-D-2), (T1-B-4) and (T1-B-7) were not tested during this test. However, they are covered under Docket 1141 and will be reported on when this docket is finalized. (See Test Procedure in Appendix)

Conclusions

All items tested are acceptable for production except for those listed above, as not being tested and item T1-C-8 (bar axle mounting) which failed early in the test and was changed back to the original design as tested under Docket 1030.

Results

1. Weld and material cracked at weldment for axle mounting at rectangular tube at 872 trips on the torture track (Item T-1-C-8). Replaced with original design.
2. All other V.A. items tested completed the track test satisfactorily.

L. H. DEMING,
Test Engineering.

EXHIBIT V

April 17, 1972

TEST PROCEDURE

Docket:	1135
Basic Model:	7222 Spreader 121 cu. ft., QH 0-21
Project Title:	Structural Test for Production Approval
Account No.	7222 T

Introduction

A Value Analysis Program on the 7222 Spreaders in 1971 resulted in a number of cost reduction items that require track testing. The accompanying sheet indicates areas changed.

Preparation For Test

1. Measure the top width and mark points at the front, rear, over the axle and mid way between the axle and front. Also, measure the diagonals from front to rear. Measure from string to 5 points on the bottom and side of each hitch member. Measure from a string to 3 points to the bottom of each "Z" section box cross supports. Measure the angle of camber on each wheel.
2. Install the hydraulic end gate.
3. Weigh the machine, total, wheel and hitch weight, empty and loaded.
4. Set the tire pressure to 40 psi for the 10.00-20 truck tires, 12 ply rating.
5. Load the machine evenly with clean sand to obtain a G. V. W. of 14, 000 lbs. Cover with plastic cover.
6. Set up tractor to pull the Spreader with an offset hitch to put the Spreader on the bumps, but allow the tractor to pass between.
7. Torque all bolts to specification.

Test

1. Operate over bumps at 3 MPH for 2500 trips.
2. Alternate offset hitch every 625 trips over bumps.
3. Visually inspect machine at middle and end of each shift, paying particular attention to Value Analysis items.
4. At end of test, unload the Spreader, repeat the measurements and inspect the structure thoroughly. Check all bolt torques.

Reports

1. A Daily Report is required, written by the Test Mechanic in charge, outlining failures, repairs made, observations, daily trips and cumulative totals.
2. A Weekly Log Sheet will be required.
3. A Final Inspection Report will be required, written by the Test Mechanic in charge of test.

G. S. BOLEGOH,
L. H. DEMING,
Test Engineering.

cc: Mr. J. H. Lepp

EXHIBIT V (continued)

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HAMILTON WORKS

MENT
CT OFFICE
RKS Engineering Centre

HAMILTON, ONTARIO

February 21, 1973

H. J. MacKenzie

ETTER

SUBJECT OR FILE NO. Final Report

Docket:	1141
Basic Model:	7222-104 Cu. Ft. Mechanical Drive Manure Spreader, QH 0-19
Project Title:	Functional Test of Value Engineering Changes
Test Duration:	452 Loads

Conclusions

1. The 7222 Spreader exhibited satisfactory performance throughout the test.
2. The following Value Engineering items are given production approval:

(a) Support, 820 239 C1, left side rear
Support revised to eliminate channel chain tightener support, 820 509 C1 and chain tightener 820 599 C1.

(b) Worm box case, 820 227 C1
Eliminating both level and drain plugs and using the top bolt for the cover as the level and the bottom bolt hole drilled through case as a drain.

(c) Clutch, 820 235 C1
Material changed from a steel forging to nodular iron.

(d) Side shield left rear, 820 507 C1
Shield changed from a 3 piece to a 1 piece construction.

(e) Both front apron and beater lever controls and support revised to eliminate stop pin in levers and extending support to allow for a stop.

Results

All test data is contained in the Appendix.

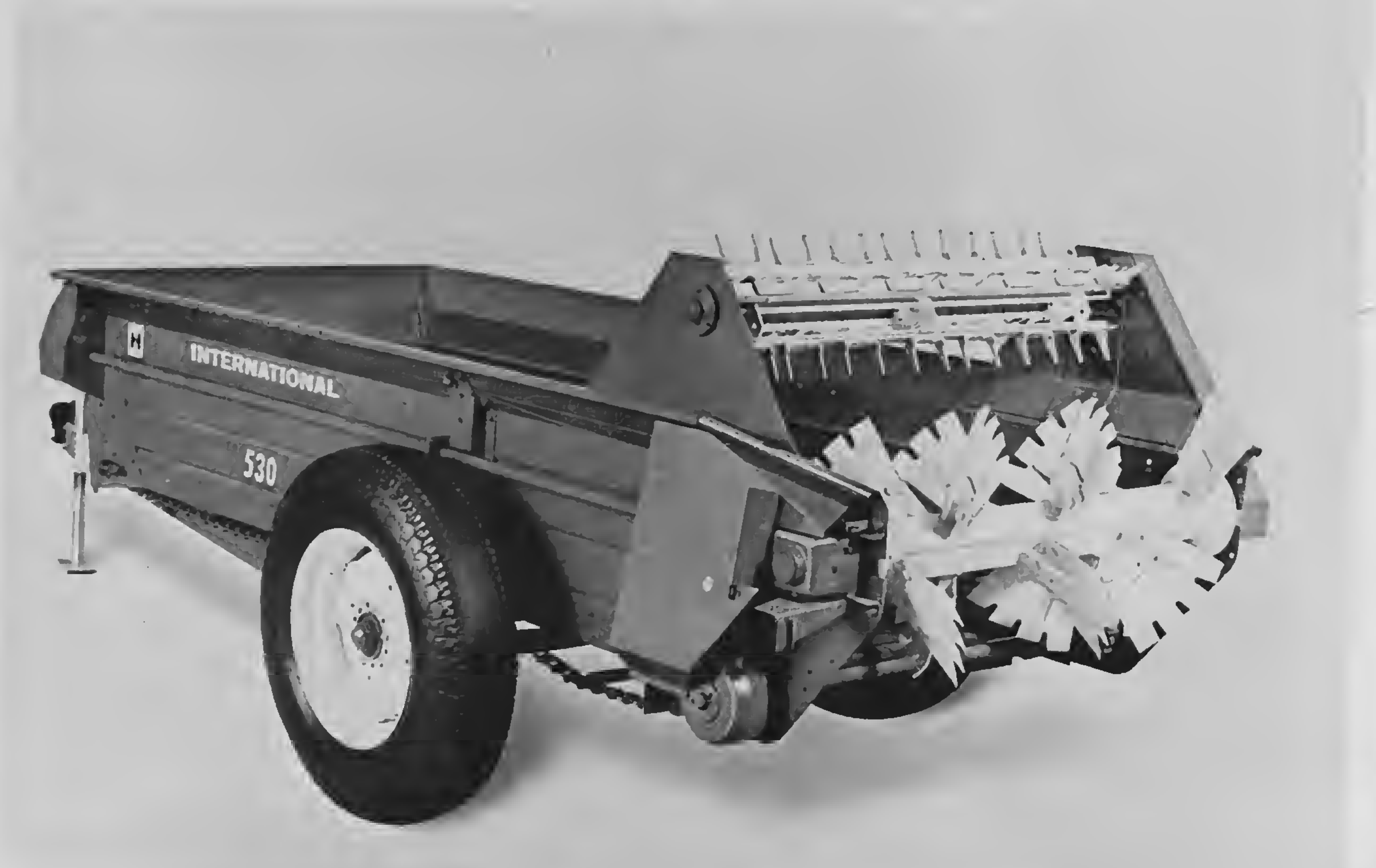
Gordon S. Bolegoh

G. S. BOLEGOH,
Test Engineering.

- Improved "Bear Claw" design is stronger and more efficient than ever.
- Underframe transmits pull directly to wheels, not through the spreader box.
- Corrosion resistant steel sides are protected by a "rust warranty."
- Beefed-up shaft nearly doubles pto capacity.
- More beater paddles per foot of width than any other spreader.
- Worm gear transmission actually lengthens life of apron by 50 to 80 percent in severe use tests.

INTERNATIONAL®

500 SERIES
Single Beater Manure Spreaders



The 530 is the smallest of the 500 Series, but still rates 148 cu. ft. heaped capacity (145 bu.), and has many features of much bigger spreaders. (Shown with upper beater.)

With the introduction of the 500 Series Manure Spreaders, International has moved years ahead of competitive machines in strength, design, and all-around practical efficiency. Wherever possible, improvements and design innovations were incorporated to make an often annoying chore a little easier, a little more trouble free. The result is a series of entirely new machines to serve today's livestock industry.

The line consists of six trailing models (530, 540, 550, 555, 570, and 580) and two truck mounted models (570 and 580) to fill the needs of almost any size of livestock operation. Two trailing models have four-wheel bogie axle arrangements.

THE "BETTER BEAR CLAW" SPREADERS FROM INTERNATIONAL

EXHIBIT VI

INTERNATIONAL 500 (B)

The development of a new product line like International Harvester's 500 series manure spreaders involves the design, testing, and evaluation of a large number of individual components. In the case of the manure spreader, the only way to effectively test the components is to operate them in the field under all possible conditions. The 500 series spreader had a number of new, untried concepts, and improvements on older components. These had to be tested and evaluated throughout the development to ensure they perform satisfactory.

To illustrate how component development takes place, let us consider the evolution of the beater design. The beater (Exhibit VII) consists of a number of "*paddles*" mounted on a shaft, which is driven directly from the power takeoff of the tractor. The beater must be ruggedly constructed and designed to cut, shred, and spread the manure as it is fed from the apron. It must be able to handle manure in many forms; soft, barn, frozen, etc. A theoretrical prediction of loading under these conditions is virtually impossible.

There had been customer complaints about the beaters on the existing model; they were bending at the base where the paddle support was welded to the shaft. This affected the spreading capability. One of the objectives set for the new design was to modify the beater and shaft system so that failures would not take place.

The beater on the production spreader was essentially the same as in Jack Lepp's original patent (Exhibit VII). It differed only in having a two piece paddle in place of the one piece paddle, with only the paddle supports welded to the shaft and with replaceable paddles bolted to the paddle supports, permitted simple replacement when the paddle claws became bent or worn.

The beaters for the Mark I were similar to the production spreader;

the paddles were made of heat treated 10 ga. steel, the paddle mounts were also of 10 ga. steel. During the field tests of the Mark I in 1967 the beater proved to be unsatisfactory. The paddle supports tore off at the roots after spreading less than 250 loads.

In preparing to design the Mark II beaters Hugh Mackenzie had strain gauge measurements made on the old beaters to give some idea of the loads. For the new design Hugh decided to use 4 x 4 square tubing for the shaft. This made the welding easier and provided longer and stronger welds. Since the company was already using 4 x 4 square shafting on several other products, there was no cost penalty. The paddles and paddle supports were heavier 8 ga. heat treated steel (Exhibit VIII).

The Mark II was field tested through 1968 and 1969. The beaters were unsatisfactory. The test report state, *"The paddles were subject to broken teeth, bending in the middle and bending of the supports before these were gusseted. The gusseted supports appeared to be adequate, but improved paddles are required."*

After the first failure, the supports had been beefed up by adding a "U" shaped gusset in the centre. This gusset provided additional stiffening which strengthened the beaters, but the weld on the gusset showed cracks after 700 loads.

The tests were not altogether discouraging, an unexpected bonus was realized in the use of square shafting. Baling twine did not wrap around it as easily as it did on the round shafts. This had been a continuous source of annoyance.

The final report of September 22, 1969, on the Model II pointed out, *"Seven failures of the teeth on the 8 ga. paddles occurred due to stones and frozen manure. The paddles also bent at the base. These paddles were not acceptable as tested. The paddle supports with gussets yielded and cracked the weld to the outer end of the gusset when operating in frozen conditions. The new design must be better, since the one tested was not satisfactory."*

Although the results were not satisfactory, Hugh felt that the tests and the resulting experience had given him a better grasp of the problem. On the basis of this he introduced some new changes (Exhibit IX). He widened the paddles for increased surface contact, he increased the number of paddles to produce a finer spread and to lower the average load per paddle, and he changed the paddle angle.

Because of these changes, Hugh knew that his previous strain gauge data was no longer valid. He asked Test Engineering to make new measurements when they were testing the Mark III at Mr. Pleasant, Ontario. The spreader was instrumented with strain gauges on both the apron and beater shafts to measure the torques. The following results were obtained:

BEATER TEST RESULTS ON MARK III

Maximum torque in frozen manure	485 ft-lbs
(Reverse)	150 ft-lbs
Average torque per load in frozen manure	360 ft-lbs
Average h.p. per load in frozen manure	22.4 h.p.
Maximum torque in soft manure	320 ft-lbs
Average torque per load in soft manure	132 ft-lbs
Average h.p. per load in soft manure (Normal apron speed)	8.2 h.p.
Average h.p. per load in soft manure (Maximum apron speed)	14.9 h.p.
Maximum torque in loafing barn manure	685 ft-lbs
Average torque per load in loafing barn manure	505 ft-lbs
Average h.p. per load in loafing barn manure	31.3 h.p.

Ian Moore, the test engineer noted, "*In frozen manure, the beater torque ranged from zero to maximum during each revolution, and on some occasions even went into reverse. On the other hand, beater torque was fairly constant (25% variation) during work in soft and loafing barn manure.*"

Hugh's design was still not satisfactory. Burkholder, who was responsible for the field testing of the Mark III noted after running 759 loads

that "*many paddles were lost and broken in frozen manure. No problem existed with normal unfrozen manure, but the problem requires consideration. The bending occurs at the edge of the support and the cracking occurs at the outer edge of the bolt holes. More contact area between the paddle and support and narrower paddles along with larger supports would help.*"

As a posative observance Burkholder added at the end of his report, "*Spreading was definitely superior to previously observed production machines.*" This report was issued on May 19, 1970.

On the strength of Burkholder's tests and recommendations, Hugh made some further changes to the beater design for the Mark IV. Beater failures continued to plague the field testing of the Mark IV. Hairline cracks were appearing in the mounts and beaters were breaking. The beater failures were now critical, and the failures were more extensive than the ones on the old line of spreaders. Hugh decided that some comparative laboratory tests were needed. Hugh asked that the new and old paddle arrangements be structurally tested to determine the maximum stress levels.

Gordon Bolegoh in Test Engineering constructed a test rig using a dummy beater with strain gauges located around the base of the paddle for the old and new beater designs. The results were:

TEST RESULTS CONCERNING BEATER FAILURES

	175 Spreader	Experimental Spreader
Load	400 ft-lbs	400 ft-lbs
Stress at failure region	50,000 psi	61,000 psi
Average Stress	18,000 psi	14,800 psi
Stress concentration factor	2.8	4.1

Bolegoh concluded his report with, "*The stress concentration is too high at the end weld of the paddle support. This stress concentration must be reduced significantly prior to giving production approval on the beater unit.*"

It was about this time at the end of 1971 that Hugh Mackenzie was made Chief Test Engineer and Jack Lepp took over the manure spreader development.

Jack made further changes in the beater paddle support orientation and asked for this new design to be evaluated. Ian Moore made the tests. This time strain gauges were not used. He wanted to be sure he was measuring the highest local stress and thus Ian decided to use a photoelastic coating.

A photoelastic coating is a bifringent plastic that is coated directly onto a part to be tested. When the part is loaded the coating conforms to the strain in the part. When the coating is viewed under polarized light, it displays the stress distribution as a colored pattern.

Moore's test report states:
"A revised beater paddle support has been tested on our loading fixture at the same load level of 400 ft lbs as our previous test. The highest stressed area was again in the welded connection between the paddle bracket and the square tube. However, a significant reduction was observed as follows:"

Maximum measured stress	49,000 pse
Stress concentration factor	3.3

"Further, it was decided to check the relative stress levels at the leadind and trailing edges of the bracket connection with <u>both</u> a normal frontal load on the paddle and a reversed load. These results were obtained:

Force on leading edge of paddle	stress	front	+67,000 psi
		rear	-57,000 psi
Force on trailing edge of paddle	stress	front	-68,000 psi
		rear	+30,000 psi

"These results indicate that increased fatigue life would not be obtained by reversing the paddle assembly."

Because of the stress patterns revealed by the photoelastic tests Jack modified the paddle brackets by reversing the paddles and incorporating a stress relief notch on the trailing end.

This was also tested by Ian Moore:
"A modified paddle bracket has been tested incorporating a stress relief notch on the trailing edge and intended to be used in the reverse manner (leading edge becomes trailing edge). This revised definition is used below:

Force on leading edge of paddle maximum stress	front	+31,000 psi
	rear	-43,000 psi
Force on trailing edge of paddle maximum stress	front	+63,000 psi
	rear	-46,000 psi

"The stress levels are now considered satisfactory for a load on the leading edge. The reverse loading measured during work in frozen manure did not exceed 40% of the forward load."

The design was now satisfactory from a stress point of view. However, if he went with a stress relief notch on only one edge, Jack Lepp realized that he would require two different paddles, a left hand and a right hand. This would increase the manufacturing costs. Before fixing the design he asked for tests to be carried out on paddle brackets with the stress relief notches on both edges. When they were tested the stress levels only increased by 5%. This was not considered significant enough to return to the single notch design.

The paddle with notch in both edges became the final design for the production model.(Exhibits X,XI,XII) The design was extensively field tested with all manner of loads. No failures were reported.

This was the work necessary to develop new beaters. Similar developments were carried on by the same engineers, at the same time, to develop the hydrostatic apron drive, the main frame of the spreader, and many other components. They very rarely had time to focus their attention continuously on one component only.

March 30, 1965 J. H. LEPP 3,175,830

SINGLE BEATER MANURE SPREADER

Filed Feb. 26, 1963 3 Sheets-Sheet 1

Fig. 1

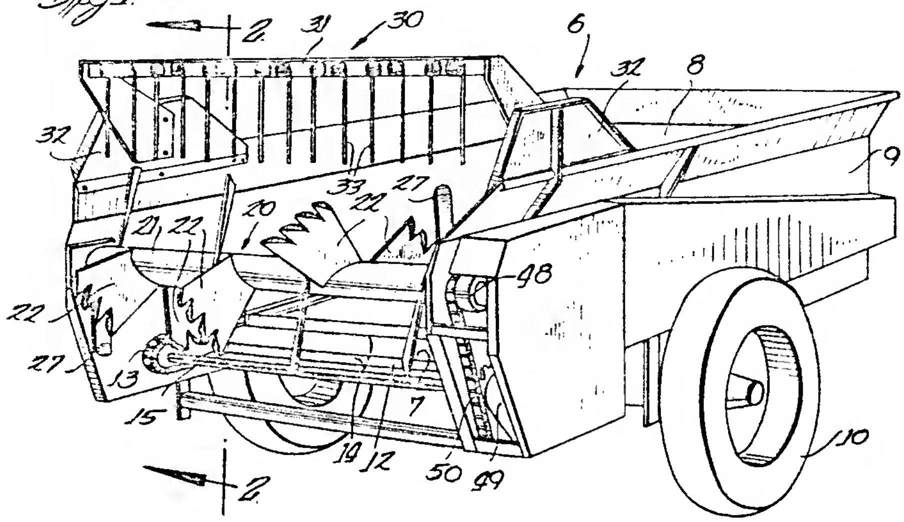


Fig. 2

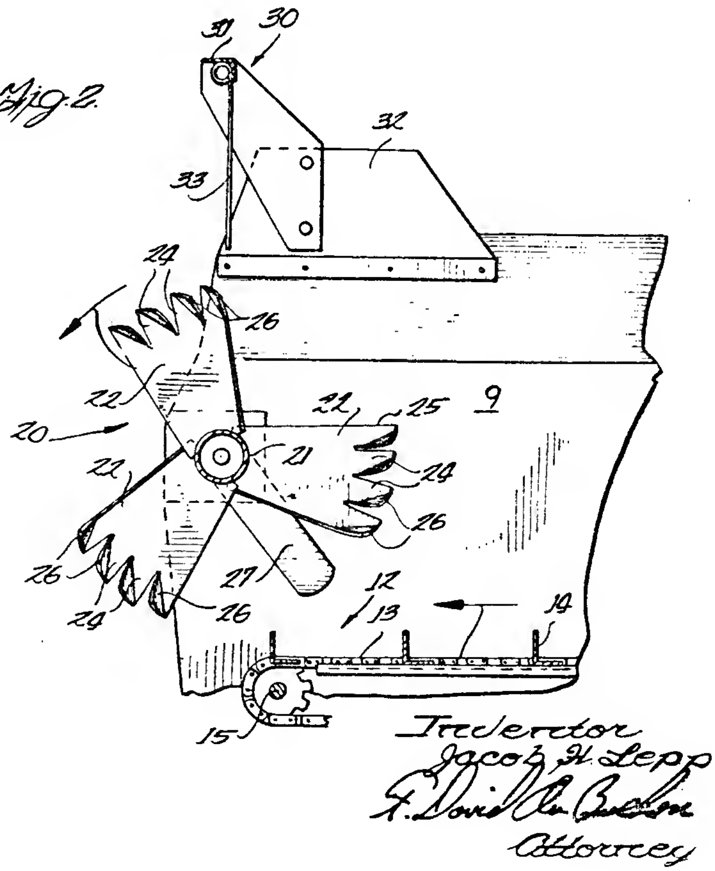


EXHIBIT VII

March 30, 1965 J. H. LEPP 3,175,830

SINGLE BEATER MANURE SPREADER

Filed Feb. 26, 1963 3 Sheets-Sheet 2

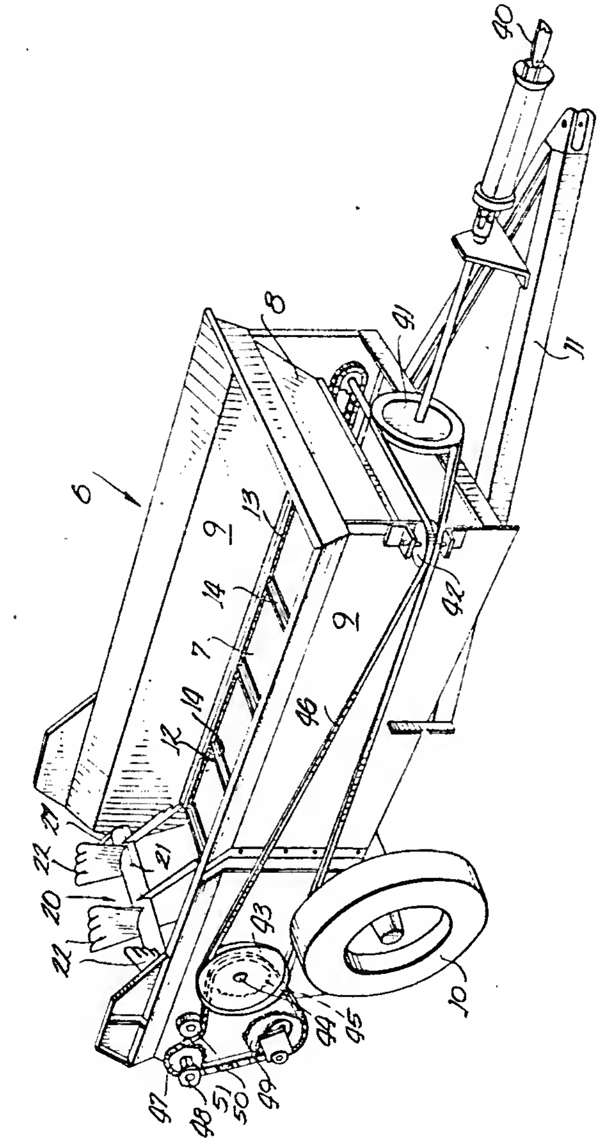


Fig. 3

Inventor
Jacob H. Lepp
F. David[illegible]
Attorney

EXHIBIT VII (continued)

March 30, 1965 J. H. LEPP 3,175,830

SINGLE BEATER MANURE SPREADER

Filed Feb. 26, 1963 3 Sheets-Sheet 3

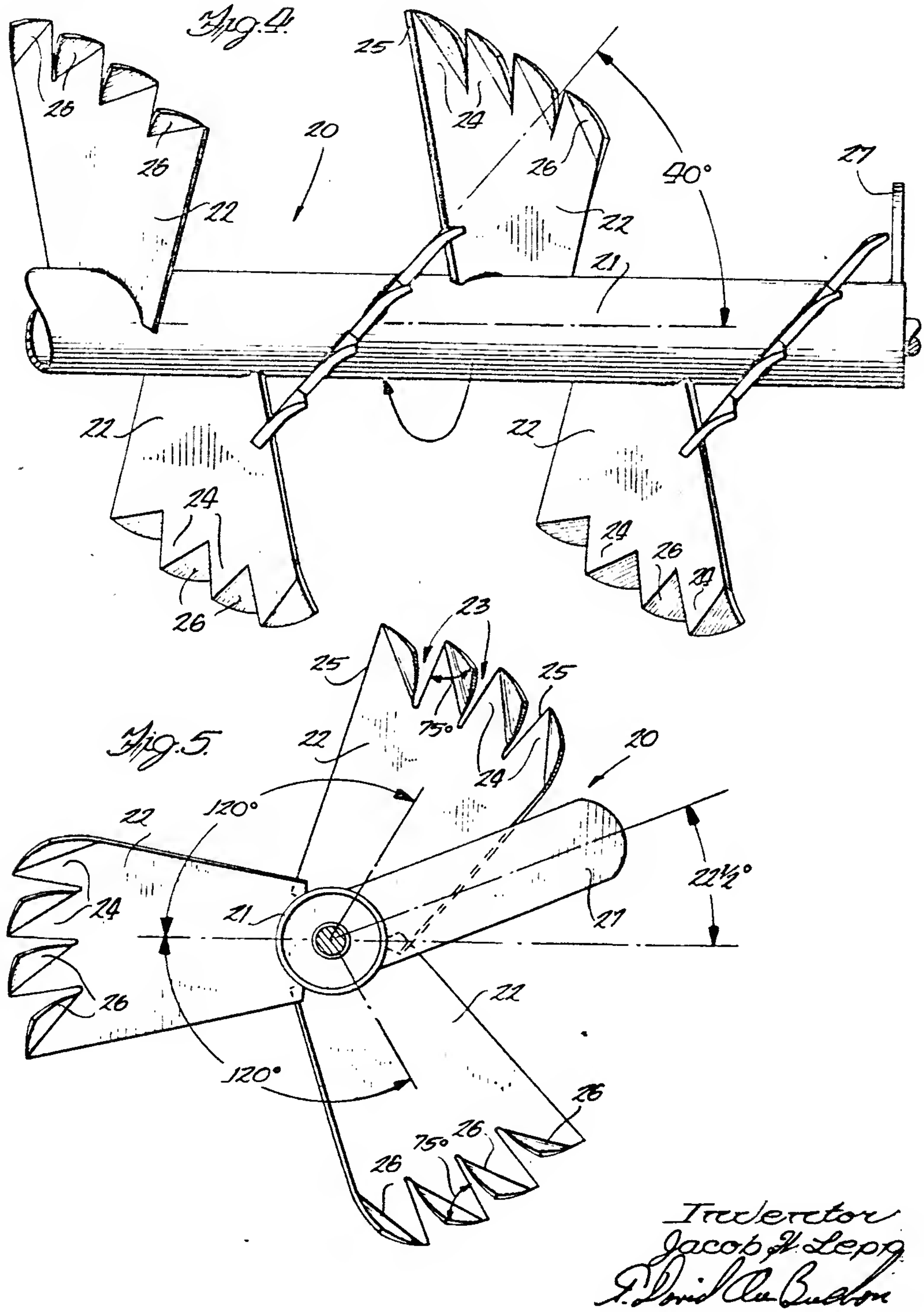
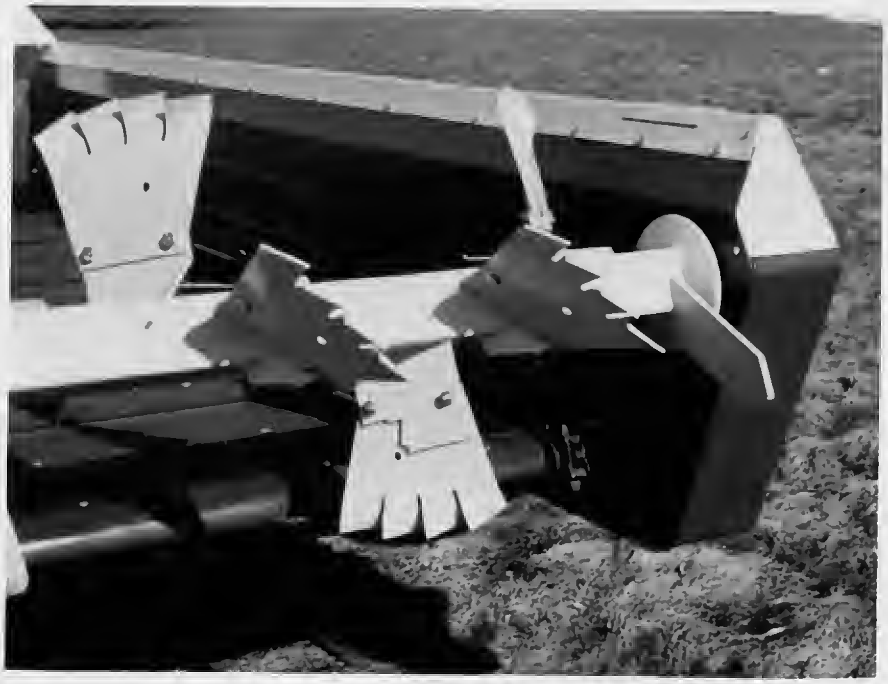
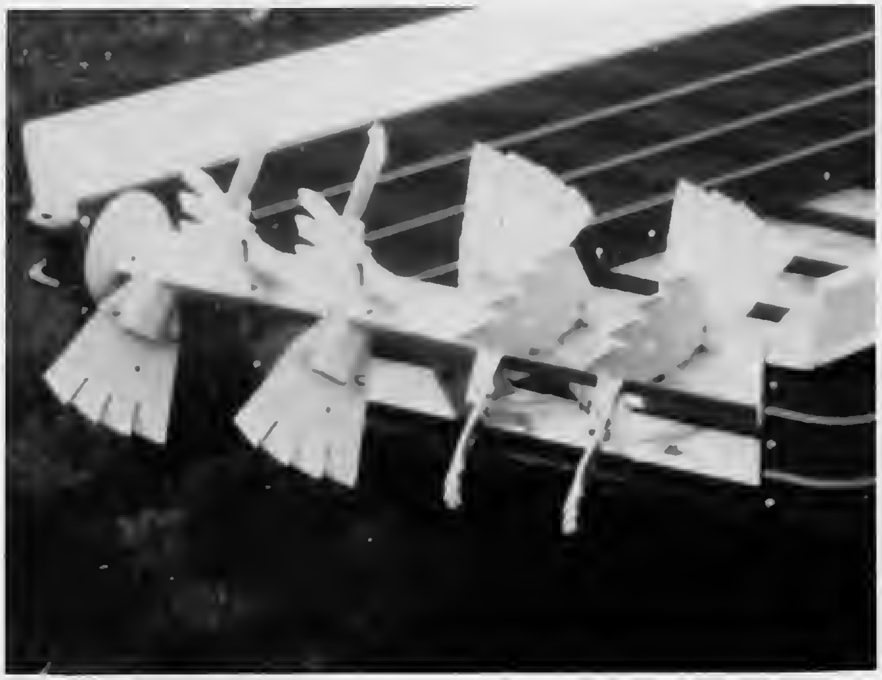


EXHIBIT VII (continued)



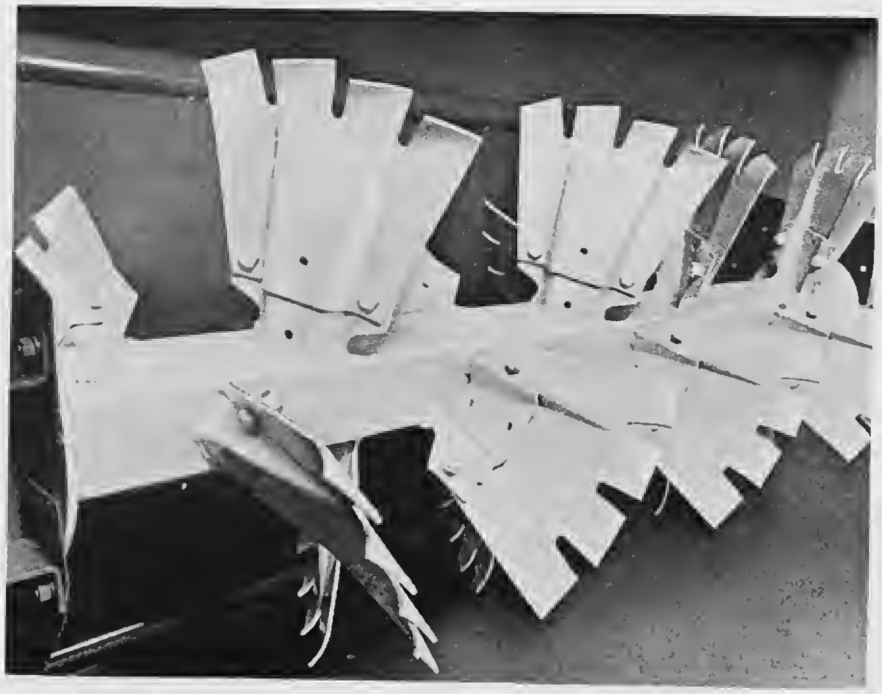
MARK II PROTOTYPE BEATER

EXHIBIT VIII



MARK III PROTOTYPE BEATERS

EXHIBIT IX



PRODUCTION BEATERS

EXHIBIT X

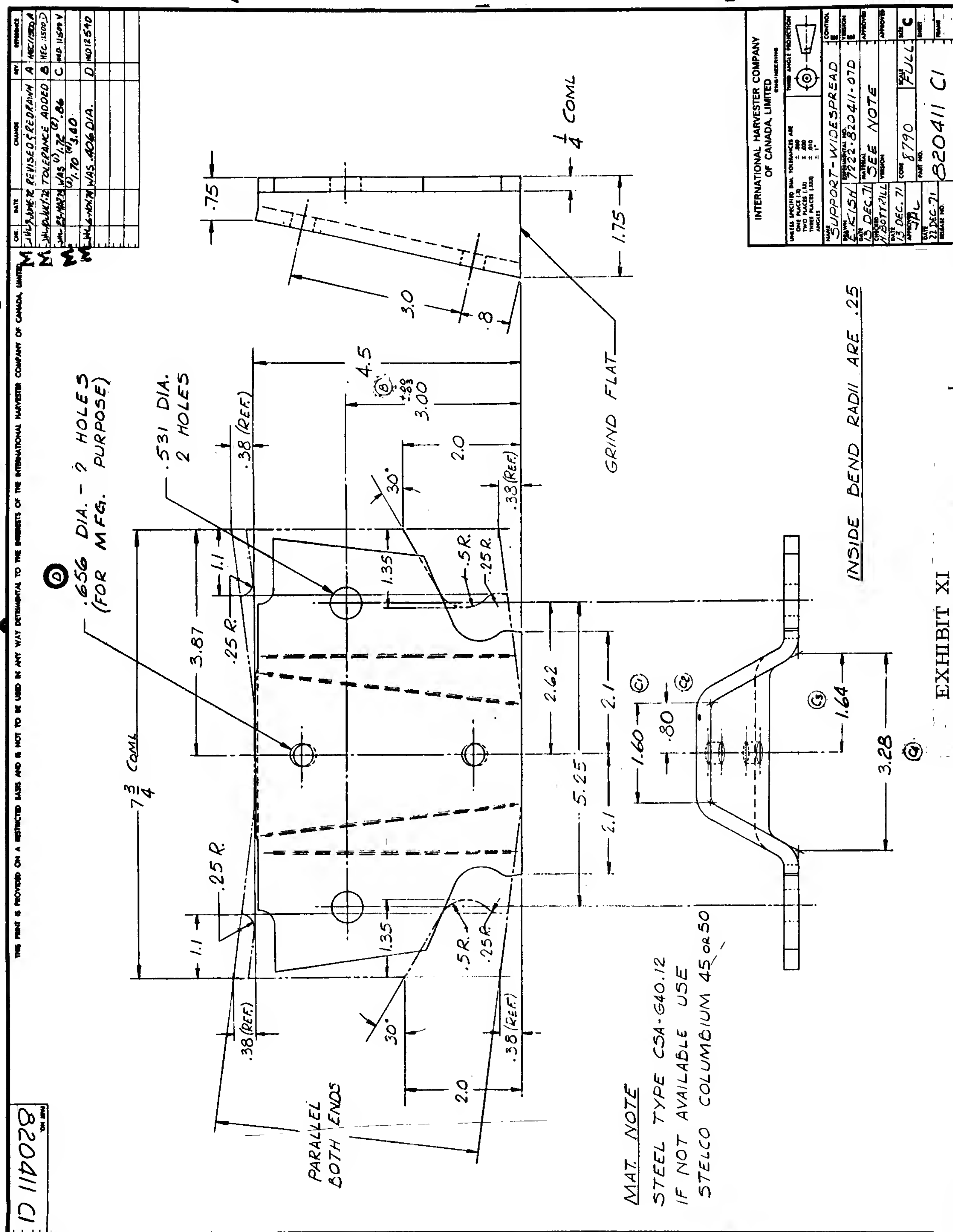

INTERNATIONAL HARVESTER COMPANY OF CANADA, LIMITED
SUPPORT-WIDESPREAD
820411 C1
INSIDE BEND RADII ARE .25
GRIND FLAT
MAT. NOTE
STEEL TYPE CSA-G40.12
IF NOT AVAILABLE USE
STELCO COLUMBIUM 45 OR 50
PARALLEL BOTH ENDS
.656 DIA. - 2 HOLES (FOR MFG. PURPOSE)
.531 DIA. 2 HOLES

EXHIBIT XI

ECL 234 B

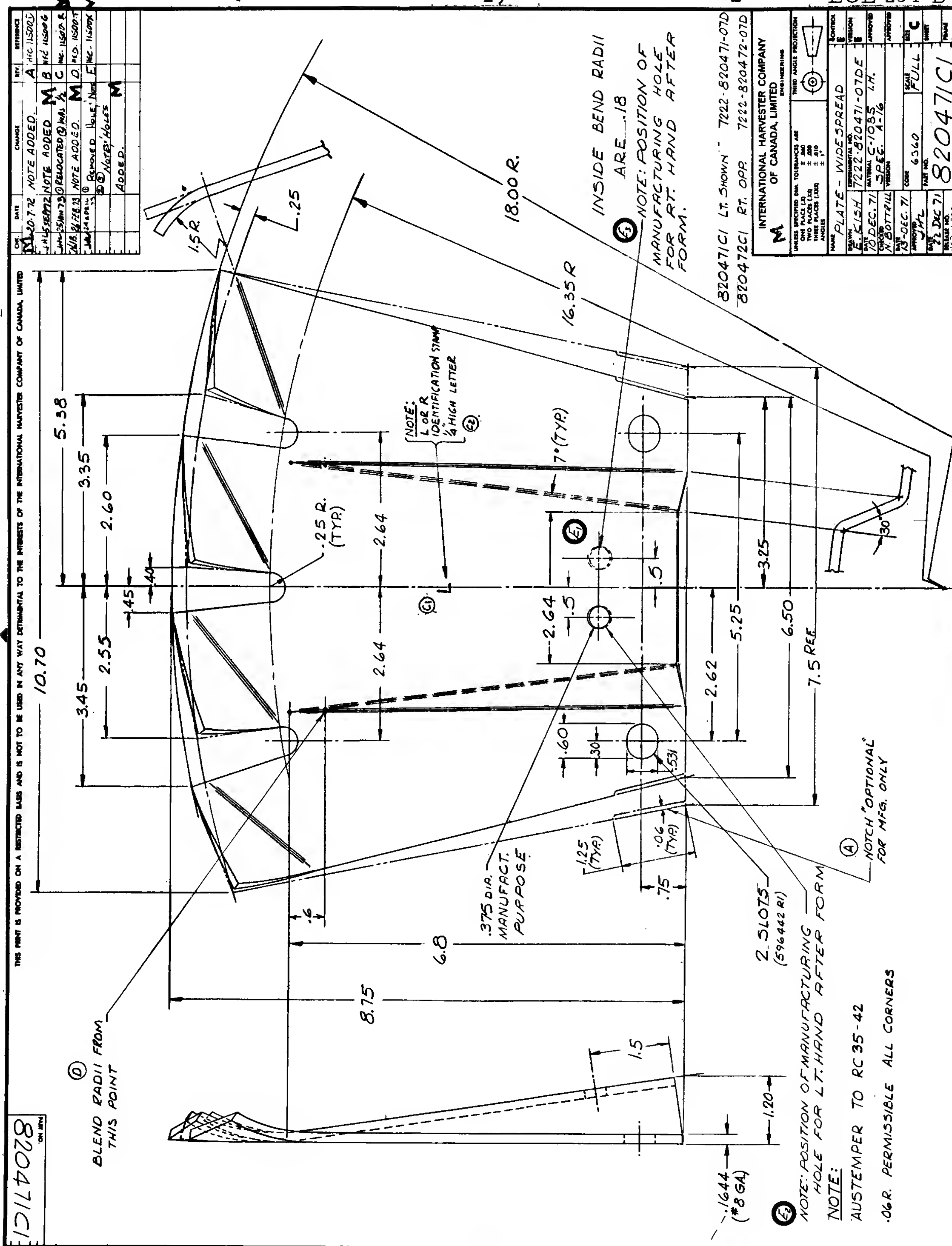


EXHIBIT XII